The Cuoricino and CUORE Double Beta Decay Experiments [1]

M. Dolinski[1,2], T.D. Gutierrez[1], R. Maruyama[1,2], B. Quiter[1,2], A.R. Smith[1], N. Xu[1]

[1] *Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720*

[2] *University of California, Berkeley, CA 94720*

Discovery of neutrinoless double beta decay ($0\nu2\beta$) is one of the top two priorities in neutrino physics as described by a recent APS Multi-Divisional Neutrino Study [2]. LBL is currently involved in a $0\nu2\beta$ experiment called Cuoricino, a TeO_2 bolometer operating at the Gran Sasso National Laboratory (LNGS) in Italy. It is the largest $0\nu2\beta$ experiment to date and is poised to place the strictest upper limits on the rate of this exotic process. CUORE (Cryogenic Underground Observatory for Rare Events) is a proposed [3] next-generation experiment based on the same bolometric principles as Cuoricino.

CUORE and Cuoricino utilize "source=detector" cryogenic bolometry: the detector material serves also as the source of the decay. When operated at low temperatures, these detectors have a heat capacity so small that even the tiny energy released by a single radioactive decay can be observed and measured by means of a suitable thermal sensor. With single crystal masses near to a kilogram and with sensitive NTD Ge (Neutron Transmutation Doped germanium) themistors, we have reached an energy resolution of about 3.9 keV FWHM of the 2615 keV ^{208}Tl line near the 2528 keV $0\nu2\beta$ region of ^{130}Te (with an average resolution over all crystals of 8 keV). In addition, thermal detectors allow a wide choice of nuclei to be used for double beta decay searches.

We are presently engaged in the Cuoricino experiment at the LNGS and in R&D for CUORE. Cuoricino is an array of 44 crystals of TeO_2 each 5x5x5 cm and 18 crystals each 3x3x6 cm. With its mass approximately 40kg of TeO_2, Cuoricino is by far the most massive cryogenic set-up in operation. Due to the large isotopic abundance (34%) of the double beta decay candidate ^{130}Te, no isotopic enrichment is required, but two of the 3x3x6 cm crystals are enriched in ^{130}Te and two others in ^{128}Te to investigate two-neutrino double beta decay. In a year and half of running, Cuoricino has obtained 1.8×10^{24} years 90% c.l. limit on the lifetime of nuetrinoless double beta decay in ^{130}Te, corresponding to a limit on the effective neutrino mass ranging from 0.2 to 1.1 eV [4] depending on the value of the nuclear matrix element. This result is nearly at the level of the best limit obtained from many years of searches from the double beta decay of ^{76}Ge.

CUORE will consist of an array of 19 Cuoricino-like towers for a total of 968 TeO_2 crystals having a total mass of 760 kg. CUORE will take approximately 5 years to build in Hall A of the LNGS and is expected to go online in 2010.

The success of CUORE depends on understanding and eliminating sources of background. The background in Cuoricino near the $0\nu2\beta$ region is about 0.17 counts/keV/kg/year. This background is primarily due to surface contamination of the copper structure and crystals. Progress is being made to reduce this contamination by an order of magnitude and we can estimate a conservative CUORE background of 0.01 counts/keV/kg/year. This will allow us to probe effective neutrino masses into the inverse hierarchy region. With further background studies we hope to achieve backgrounds of 0.001 counts/keV/kg/year.

LBL is involved in three active research areas for both Cuoricino and CUORE. Our primary responsibility is the construction of the NTD thermistors for CUORE. We are also working on an independent analysis framework for both Cuoricino and CUORE using the currently available Cuoricino data. Finally, we are assisting in characterizing sources of background in various components of Cuoricino and CUORE. See the corresponding sections on Cuoricino analysis and background studies in this NSD Annual Report.

The group currently has two postdocs and two students.

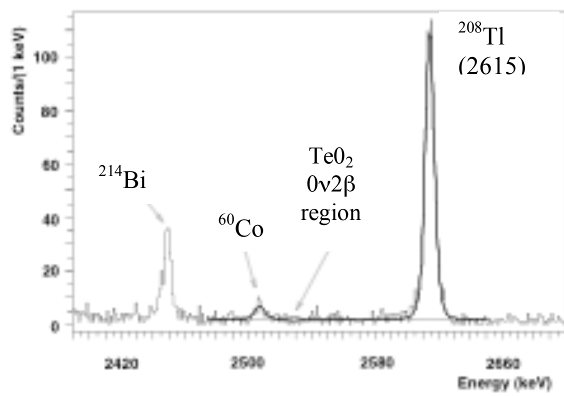

FIG. 1: Cuoricino spectra in the region of neutrinoless double beta decay (2528 keV) from [4].

REFERENCES

[1] Partly condensed from Phys. Lett. B 584, 260 (2004); Nucl. Instrm. & Meth. A 518, 775 (2004); Astropart. Phys. 20, 91 (2003).

[2] The Neutrino Matrix, American Physical Society Joint Study on the Future of Neutrino Physics (2005).

[3] R. Ardito *et al.*, hep-ex/0501010 (2005).

[4] C. Arnaboldi, *et al.*, hep-ex/0501034.